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DESCRIPTION

METHOD OF TIME AND FREQUENCY SYNCHRONIZATION OF MULTIMODE TERMINAL

Technical Field:

The invention is in the field of time and frequency synchronization of a multimode terminal with at least two different base stations. More specifically, the present invention relates to a method and a device for time-synchronizing at least two radio access modules of a multimode communication terminal capable of functioning according to at least two distinct radio access techniques in a cellular telecommunication network in which one of the radio access module is active in the current cell and the other radio access module is in a passive state in the current cell.

The invention applies to a multimode terminal such as, for example, a GSM/UMTS (Global System for Mobile Communications, and Universal Mobile Telecommunications System, respectively) dual-mode terminal.

Background Art:

Currently GSM is the mobile telephone system of reference in Europe and in the world. In order to ensure its evolution towards the third generation, ISO (International Organization for Standardization) has proposed UMTS. Technical specifications of UMTS are developed under a partnership called 3GPP (Third Generation Partnership Project). One thing desired in the process of standardizing UMTS was to ensure its interoperability with GSM. Thus, a specific classification describing four types of dual-mode GSM/UMTS terminals, Type 1, Type 2, Type 3, and Type 4 was established.

For terminals of Type 1, when a terminal is located in a GMS radio network or in a UTRA (Universal Terrestrial Radio Access) radio network, the "inactive" radio part of the terminal (UTRA or GSM) does not perform any

measurement of reception quality, with the implication that transition from one mode to the other can only be made with intervention of the user.

For terminals of Type 2, when a mobile terminal is connected to a GSM radio network or to a UMTS radio network, the inactive radio part of the terminal (UTRA or GSM) may perform measurements in order to switch automatically to the network that provides the better reception quality.

Terminals of Type 3 are different from those of Type 2 in that they further provide the possibility of receiving information simultaneously in both modes. On the other hand, simultaneous transmission in both modes is not possible. As with terminals of Type 2, transition from one radio network to another is performed automatically.

For terminals of Type 4, transition from one radio network to another is performed automatically, and information may be received and transmitted simultaneously over the two networks.

The present invention finds applications in terminals of Type 2 as well as in those of Type 1. Note that among the four types of terminals of this classification, it is the dual-mode terminals of Type 2 that allow the operators to make current investments in GSM profitable, taking advantage of the existing coverage while familiarizing their subscribers with new services provided by UMTS.

At the level of functional architecture, a Type 2 terminal comprises an electronic card responsible for performing tasks specific to GSM and an electronic card that performs tasks specific to UMTS. In this type of terminal, at a given moment, one card is necessarily active and the other is inactive. Consequently, at that moment, only communication with the network associated with the active card (GSM or UMTS) is possible. The inactive card can only perform measurements on neighboring cells belonging to the other radio access network (GSM or UMTS). The measurements possibly serve for switching automatically

from a GSM network to a UMTS network and vice-versa.

Recall that in a single-mode terminal (GSM or UMTS), in order to avoid relative frequency error between the reference clock in the electronic card (GSM or UMTS) and the clock of the base station of the network (GSM or UMTS), it is necessary for the terminal to be synchronized with the associated network in time and frequency to be able to decode and then demodulate information coming from the base station. This error may have several causes among which are variations of temperature or even aging of components of the terminal.

In order to compensate for this error, a very common technique used in the prior art called AFC (Automatic Frequency Control) consists in ensuring frequency synchronization with the current base station to be as precise as possible with the aid of a closed loop that is slaved to a reference frequency value. The loop is supplied with estimations of frequency errors measured on the downlink channels that the mobile is listening to.

The object of the invention is to update the time base of the passive radio access module with respect to that of the active radio access module. The time base defines a whole set of counters of time-measuring units used in each radio access technology.

Another object of the invention is to optimize the autonomy of the mobile terminal by maintaining one of the radio access modules in the "sleep" state as much as possible while preserving its synchronization with the network by means of the active radio access module. This should allow the inactive radio access module to perform measurements on neighboring cells of the same radio technique in time windows allocated by the current radio network.

Disclosure of the Invention:

The present invention proposes a method of time synchronization of radio access modules of a multimode communication terminal capable to communicate

with base stations of a cellular telecommunication network via a plurality of distinct radio access networks, each based on at least a first radio access technique and a second radio access technique different from the first radio access technique, one of the radio access modules being active in a cell of the network called current cell, while the other radio access modules being passive in that cell.

The method according to the invention comprises the following steps:

(a) measuring for each of the cells adjacent to the current cell a time offset T_{offset} between the start of a specific frame of the first radio technique and the start of a specific frame of the second radio access technique; and

(b) using the time offset T_{offset} measured in step (a) for synchronizing the passive radio access module with the active radio access modules.

The method according to the invention may further comprise a step consisting in activating the passive radio access module from the active radio access module when measurements of power should be performed by the passive radio access module.

The method according to the invention may further comprise a step consisting in updating the value of the offset T_{offset} on each change of the current cell.

According to a preferred embodiment of the invention, the mobile terminal is a UMTS/GSM dual-mode terminal and the predefined duration T_{offset} is the time difference observed on a GSM cell defined in the standard 3GPP TS 25.215.

The invention thus makes it possible to take advantage of the measurement specified in the UMTS standard called "Observed time difference to a GSM cell" or "OTD." This measurement is used by the UMTS network for placing in time sequence compressed frames used for performing measurements of power on GSM cells. It represents the time offset between the start of the UMTS superframe of the current cell having a size of 4096 frames of 10 ms and

the start of a GSM multiframe of a neighboring GSM cell having 51 frames of 4.615 ms.

Typically, this measurement is performed upon request from the network. However, within the present invention, the "observed time difference to a GSM cell" will be measured as needed by the terminal.

According to the invention, activation of the passive radio access module may be performed just before performing measurements on neighboring cells of the current cell.

The invention also relates to a device designed to implement the method according to the invention, the device comprising:

means for measuring a time offset T_{offset} between the start of a specific frame of the first radio technique and the start of a specific frame of the second radio access technique; and

means for generating a clock signal of the passive radio access module shifted with respect to the clock signal of the active radio access module concerning the duration T_{offset}.

The invention also relates to a multimode mobile terminal comprising:

a radio access module dedicated to each operating mode;

a clock generator associated with each radio access module; and

a unit for calculating a time offset T_{offset} between the start of a specific frame of a first operating mode and the start of a specific frame of a second operating mode in a cellular telecommunication network.

This terminal further comprises a central interface capable to generate a clock signal in the passive radio access module shifted with respect to the clock signal of the active radio access module by the duration T_{offset}.

According to the invention, the central interface may comprise a module for generating an order for activating the passive radio access module.

Brief Description of the Drawings:

Other characteristics and advantages of the invention will be apparent from the following description, taken by way of non-limiting example, with reference to accompanying drawings in which:

FIG. 1 schematically represents a device designed to implement the method according to the invention;

FIG. 2 schematically represents a particular embodiment of the unit for calculating the difference of time observed in a GMS cell defined in the standard 3GPP TS 25.215;

FIG. 3 represents a timing chart allowing to schematize the time offset perceived by the mobile terminal between the starts of the UMTS superframe having a size of 4096 frames and the start of the GSM multiframe having 51 frames; and

FIG. 4 schematically shows the way in which the passive radio access module (GSM) is awaken by the active radio access module (UTRA) for the purpose of examining neighboring GSM cells.

Best Mode for Carrying Out the Invention:

The invention will now be described in an application in a UMTS/GSM dual-mode mobile terminal set to a UMTS cell by way of example. Thus, the active radio access module is UTRAN (Universal Terrestrial Radio Access Network or UMTS Terrestrial Radio Access Network), and the passive radio module is that of the GSM system.

In FIG. 1, a device for time-synchronizing UTRAN and GSM is shown. The device comprises: a UTRA radio access module 2 connected to a clock 4 of 19.2 MHz; a GSM radio access module 6 connected to a clock 8 of 13 MHz; and a time base module and generator 12 comprising a first unit 14 designed to maintain the clock signal of the UTRA module 2, a second unit 16 designed to maintain the

clock signal of the GSM module 6, and a unit 18 for calculating the duration T_{offset} representing the difference of time observed on GSM defined in the standard 3GPP TS 25.215.

Each of elements described above is connected to a central interface 20 programmed for generating a clock signal calculated from the 19.2 MHz UTRA clock signal, the 13 MHz GSM clock signal, and the time offset T_{offset}. The central interface 20 is further connected to the central processing unit (CPU) 21 of the mobile terminal. The device is further provided with a clock 10 of 32 KHz and the clock signal of 32 KHz is supplied to the UTRA module 2, GSM module 6 and time base generator 12.

With reference to FIG. 2, the calculation unit 18 comprises a counter 22 connected to the first unit 14 and the second unit 16, and receives from the central interface 20 a command signal to start the counting at the start of the UMTS superframe of the current UMTS cell having a size of 4096 frames to the start of a GSM multiframe of a neighboring GSM cell having 51 frames.

In FIG. 3, the start of the UMTS superframe is illustrated by arrow 24, and the start of the GSM multiframe of a neighboring GSM cell having 51 frames is illustrated by arrow 26.

Note that the measurement of the duration T_{offset} is performed only once at the moment the mobile terminal is set to the cell for the first time, and then updated regularly according to the technique described in the following paragraphs. This measurement will have to be performed again if the active cell changes, or if a new GSM cell appears in the radio environment of the mobile. Also this measurement has to be carried out for each GSM cell adjacent to the active UTRAN cell. The estimated duration T_{offset} will be used for updating the time base of the passive radio access module with respect to the active radio access cell and this is done for each neighboring GSM cell.

The time base is defined here as a set of counters of time measurement units used in each radio access technique. For example, in GSM, it is necessary to keep updated the counts of symbols, slots, frames, and multiframes. These counters constitute the GSM timing unit (GTU) in FIG. 1. Similarly, in UMTS, it is necessary to keep the counts of time measurement units of the information transmitted in the current cell. These measurement units are chips, slots, and frames.

The following expression allows for updating the GSM time base from the UMTS time base from the measurement of T_{offset}:

$$GSM\_Time = \left[(UTRA\_fn \times 10) + \left(UTRA\_sn \times \frac{10}{15} \right) + \left(UTRA\_cn \times \frac{10}{38400} \right) - T_{offset} \right]$$

where UTRA_fn represents the value of the frame counter, UTRA_sn represents the value of the slot counter, and UTRA_cn represents the value of the chip counter in UMTS.

The value of GSM_Time is then used to estimate the corresponding values of a superframe, a frame, a slot and a quarter of GSM bit according to the following expressions:

$$GSM\_sfn = INT\left[\frac{GSM\_Time}{(3060/13)} \right]$$

$$GSM\_fn = INT\left[\frac{GSM\_Time}{(60/13)} \right] MOD(51)$$

$$GSM\_sn = INT\left[\frac{GSM\_Time}{(15/26)} \right] MOD(8)$$

$$GSM\_qb = INT\left[\frac{GSM\_Time}{(15/16250)} \right] MOD(625)$$

Similarly and given that a GSM frame amounts to 60/13 ms, and that a GSM slot amounts to 15/26 ms and that a quarter of a GSM bit is 15/16250 ms,

UMTS base time may be obtained from the GSM base time according to the following expression:

$$UTRA\_Time = \left[\left(GSM\_fn \times \frac{60}{13}\right) + \left(GSM\_sn \times \frac{15}{26}\right) + \left(GSM\_qb \times \frac{16}{16250}\right) + \left(N \times 51 \times \frac{60}{13}\right) + T_{offset}\right]$$

where GSM_fn, GSM_sn and GSM_qb represent the number of frames, slots, and quarter GSM bits respectively. Thus, we have:

$$UTRA\_fn = INT\left[\frac{UTRA\_time}{10}\right] MOD(4096)$$

$$UTRA\_sn = INT\left[\frac{UTRA\_Time}{(10/15)}\right] MOD(15)$$

$$UTRA\_chip = INT\left[\frac{UTRA\_Time}{(10/38400)}\right] MOD(2560)$$

In operation, the UMTS radio part performs the measurement T_{offset} as specified by the recommendation 3GPP TS 25.215 with the aid of the device represented in FIG. 2. The databases containing time measurement units 14 and 16 described above are initialized with the measurement T_{offset}.

An exemplary application of the invention is as follows: When the mobile terminal is synchronized with a UMTS cell and the mobile terminal is communicating with the network in a dedicated channel, spots are allocated by the network to the mobile where measurements on GSM cells are to be performed. Then it is necessary for the GSM RAT (radio access technology) to know exactly the start and the end of these spots. For this, the UMTS time is converted into GSM time according to the expressions described above in order to achieve the synchronization and then to synchronize the two GSM and UMTS radio cards so as to know the exact time to awaken the GSM card while allowing the card to remain synchronized with respective GSM cells.

Note that, by virtue of the invention, it is not necessary to perform the measurement T_{offset} systematically. In fact, once the value T_{offset} is measured for

the first time as specified by the recommendation 3GPP TS 25.215, the fact that the active radio access module always maintains time synchronization with the network of the active cell is advantageously used. Thus thereafter it is only necessary to measure the time offset T_{offset} internally between the active radio access module and the passive radio access module without intervention of signals received from the GSM and UTRAN network. The device in FIG. 2 is used again for this purpose.

Thus, the value T_{offset} is estimated by means of the counter 22 that is supplied with UMTS and GSM frame timing signals. The start of the counting is activated by the UMTS frame timing signal and the end of the counting is controlled by the GSM frame timing signal at the end of a period defined by the manufacturer of the terminals (a few milliseconds). The precision of the measurement is determined by the 19.2 MHz clock. Once the counter is stopped, the difference of time T_{offset} between the two RAT will be obtained in number of cycles of 19.2 MHz clock. The counter is activated by an external signal that may be generated by the microprocessor of the system.

With reference to FIG. 4, at step 30, the first unit 14 sends to the central interface 20 a request for activating the passive radio access module 6. The central interface 20 transmits this request to the passive to the passive module 6 at step 32. Upon receiving this request, the passive radio access module 6 sends to the central interface 20 a synchronization demand at step 34. The central interface 20 triggers the calculation of the time offset T_{diff} by the calculation unit 18 at step 36. The result of this calculation is then transmitted at step 38 to the central interface 20, which transmits it to the first unit 14. The unit 14 generates the synchronization signal GSM_Time for estimating the corresponding values of a superframe, a frame, a slot and a quarter GSM bit. The synchronization signal GSM_Time is then transmitted to the central interface 20 at

step 40, which transmits it at step 42 to the second unit 16 designed to maintain the clock signal of the GSM module.

Once the two radio access modules are synchronized by means of the signal GSM_Time, the intersystem measurement may be carried out at step 50.

At the time a cell change, the time T_{offset} is transmitted at step 52 to the central interface 20, which transmits it at step 54 to the calculation unit 18. Upon receiving the value of T_{offset}, the calculation unit 18 performs updating of the T_{offset} and sends back at step 56 the result of the updating to the central interface 20, which transmits it at step 58 to the first unit 14. The first unit 14 recalculates the synchronization signal GSM_Time and transmits it at step 60 to the central interface 20, which transmits it at step 62 to the second unit 16.